03-2-3

Z-5267 CERAMIC TETRODE, 40 WATTS AT 3000 MC.

PRODUCTION ENGINEERING MEASURE

REPORT NO. 2

SECOND QUARTERLY PROGRESS REPORT

1 SEPTEMBER 1962 THROUGH 30 NOVEMBER 1962

CONTRACT NO. DA 36-039-SC-86735

UNITED STATES ARMY SIGNAL SUPPLY AGENCY

PHILADELPHIA, PENNSYLVANIA

CLASSIFICATION - NONE

RECEIVING TUBE DEPARTMENT

GENERAL ELECTRIC

OWENSBORO, KENTUCKY

Z-5267 CERAMIC TETRODE, 40 WATTS AT 3000 MC. PRODUCTION ENGINEERING MEASURE

REPORT NO. 2

SECOND QUARTERLY PROGRESS REPORT

1 SEPTEMBER 1962 THROUGH 30 NOVEMBER 1962

Objective: (1) To establish production techniques for assembling and testing the Z-5267 tube.

(2) To propose a final tube specification.

(3) To demonstrate 75 tube per month production capability.

CONTRACT NO. DA 36-039-SC-86735

SIGNAL CORPS INDUSTRIAL PREPAREDNESS
PROCUREMENT REQUIREMENTS NO. 15

CLASSIFICATION - NONE

REPORT BY - V. W. AMOTH

TABLE OF CONTENTS

Title		Page
1.0	ABSTRACT	1
2.0	PURPOSE	2
3.0	NARRATIVE AND DATA	3
3.1	TOLERANCES AND FIXTURES	4
3.2	ANODE CERAMIC	6
3.3	MOLYBDENUM CONTACTS	6
3.4	SUPER DRY HYDROGEN	6
3.5	EXHAUST SETS	7
3.6	CATHODE COATING	7
3.7	RADIATOR	7
3.8	ANODE SLOTTING	8
3.9	SCREEN CURRENT	8
3.10	AMPLIFIER TEST SET	8
3.11	RF STABILIZING AND LIFE TEST	9
3.12	MISCELLANEOUS	10
4.0	CONCLUSIONS	14
5.0	PROGRAM FOR THE NEXT INTERVAL	15
6.0	PUBLICATIONS, REPORTS AND CONFERENCES	16
6.1	PUBLICATIONS	16
6.2	REPORTS	16
6.3	CONFERENCES	16
7.0	PERSONNEL	17

1.0 ABSTRACT

A summary of the status of the entire program is described in detail. A few tubes have been exhausted and RF tests completed on one tube. Assemblies have been built up to provide for the contractural delivery of ten during December. Trouble is being encountered in building efficient cavities for the project.

2.0 PURPOSE

One of the objectives of this contract is to further the work of contract DA 36-039-SC-75069 and permit refinement of assembly techniques and standardization of processes and procedures which would result in a more manufacturable product. Parts processing in larger quantity along with tolerance tightening of both the parts and sub-assemblies will result in narrower tube specification limits for more consistent tube usage.

The objective test requirement is the General Electric Proposed Military Specification Sheet, Type Z-5267 dated 4 May 1962. The specification defines a ruggedized metal-ceramic planar tetrode which will produce 40 watts as a CW amplifier at 3000 megacycles. It includes a 400 G shock test, 50 to 1000 cycle vibration at 15 G and a 200 C ambient and RF life tests.

Forty engineering tubes will be supplied to evaluate various assembly improvements and aid in writing a final specification. Ten pre-production tubes will be supplied to this specification. In addition, seventy-five shippable tubes per month final production capability will be demonstrated.

Process studies will be conducted and included in an over-all Inspection and Quality Control Manual. In addition, a complete plan for producing 200 tubes per month will be submitted.

3.0 NARRATIVE AND DATA

At the start of assembly operations, it was discovered that the low volume of initial work on this tube made daily production processes impractical. Thus some time was spent building up a backlog of assembly parts before final tubes could be started. Although only four tubes were built and exhausted during this period, an additional backlog of parts is available to continue production.

The first tube exhausted showed some gas on the initial aging step which cleared up overnight. All initial aging to date has been accomplished on the static test set so that the actions of the currents, voltages and gas clean-up could be observed during the aging-in process. RF aging was continued in one of the amplifier cavities built on the previous contract. It was found that this tube resonated at about 2850 megacycles which is below the low test limit. A check back on the assembly data showed that it had a close screen-to-plate output gap which would naturally result in the low frequency data observed. After RF aging, operation at full ratings indicated power output saturation at 20 watts. The reason for this low power output is not completely understood at this time, although the static characteristics of the tube indicate lower than normal positive grid currents.

Tube number 2 showed an initial grid-to-screen short which, when burned out with voltage, promptly produced a grid cathode short. Burning out of the latter showed good performance on initial DC aging. However, subsequent aging again produced a grid cathode short. Upon burn out of this short, both the grid and screens were destroyed, ruining the tube.

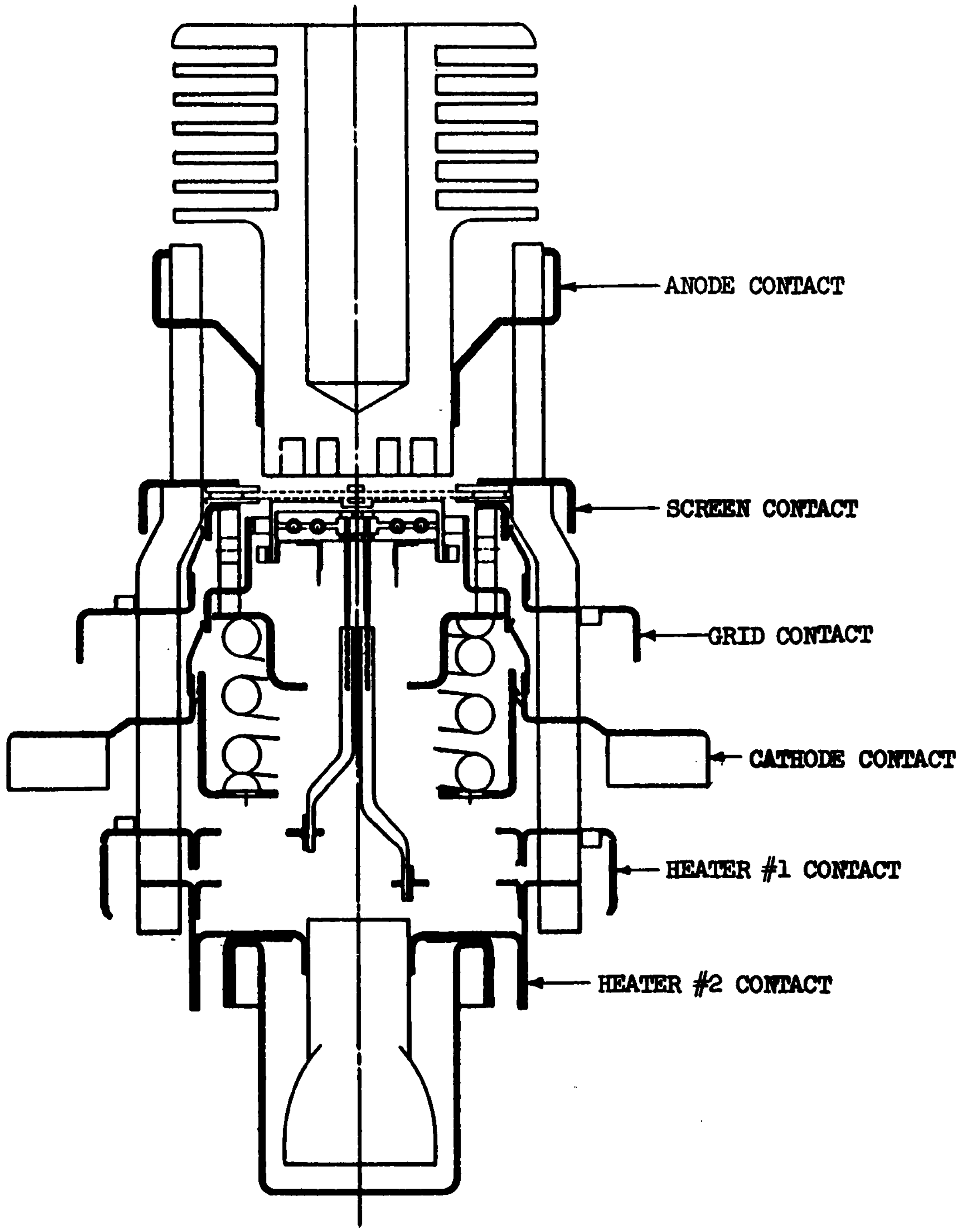
At this time tube number 3 and 4 are still in the DC aging process. Tube number 3 shows poor long pulse emission, but it has not yet had any RF operation. Tube number 4, on the other hand, shows good long pulse emission without any RF aging. Both of these tubes will be given RF operation upon completion of DC aging.

3.1 TOLERANCES AND FIXTURES

Little difficulty has been encountered in making the parts to a diameter tolerance of ± 0.003 inches versus the previous outline dimension of ± 0.005 inches. It was felt necessary to tighten the part dimensioning in order to insure that the outline dimension was not exceeded during the stress relief of firing and brazing of parts.

A study of the cross sectional drawing on the next page will reveal that this is a single ended tube, plugging into the cavity from the anode end. The anode, screen, grid and cathode contacts are rounded in this direction for easy cavity insertion. The heater contacts must be put on from the other end. It was discovered that the heater number 1 part had a sharp lip on the side of contact insertion. Heater number 2 does not have a sharp lip because the heliarc weld at this lip gives a rounded corner. It was felt advisable from an application and user standpoint to roll the edge of heater number 1 so that no marring of contacts would occur.

All of the fixtures for tube assembly have been received, except a few placed on an outside vendor due to heavy shop load



Z-5267 CROSS-SECTIONAL DRAWING

within the General Electric Company. No slow down of tube assembly has resulted, due to the availability of other fixtures for this work.

3.2 ANODE CERAMIC

Fixtures have been made with a split ring for use in centering the anode ceramic.

3.3 MOLYBDENUM CONTACTS

The slots in the molybdenum contacts are punched in the flat strip form, rolled and formed to a circular shape. Initial trials showed difficulty in getting a close enough fit to the support in order to insure brazing. A nickel tab is tack welded across the slit in the molybdenum contact and serves as a very satisfactory holder so that no further brazing problems have been encountered. This has eliminated the previous slotting after drawing, and subsequent hardening of the molybdenum, which caused flaking of chips resulting in tube element shorting.

3.4 SUPER DRY HYDROGEN

Both molybdenum contacts, in the slit form above, are brazed using nickel-gold solder in line hydrogen. This eliminates the super dry hydrogen brazing formerly used on both of these parts. The only remaining super dry hydrogen operation is that used in joining the two grids in the grid package. Tests will be made early next year to determine whether standard molybdenum-manganese brazing will be satisfactory on this grid package. If so, super dry hydrogen will be eliminated altogether.

3.5 EXHAUST SETS

The major portion of the exhaust sets have been rebuilt. Plans are to cover the bottom part of the set with cabinets in order to facilitate keeping the exhaust area clean. The ovens will be controlled by an automatic temperature controller.

Tubes to date have been run one at a time on an older exhaust set. The bake-out and breakdown schedules have been varied on the first four tubes to determine an optimum schedule. Difficulty was encountered in trying to reach the 550°C bake out temperature by burning out a 250 watt lower calrod unit. 350 watt heaters were ordered which also promptly burned out. A discussion with the vendor revealed that we should leave an air space between the calrod and any insulation or mount the calrod on a metal plate. The exhaust set is now being modified to leave an air space.

3.6 CATHODE COATING

The initial trial of the cathode grinding fixture occasionally produced a gouge in the cathode. In addition, it appeared to give variable heights during grinding. A careful check of the fixture showed a small burr under the cathode. Upon removal of the burr, the grinding fixture operated satisfactorily with a tolerance of 0.0002 to 0.0003 inches.

3.7 RADIATOR

No effort was spent on producing a reuseable radiator during this period due to efforts toward building operable tubes. This work is scheduled to commence after the first of the year.

3.8 ANODE SLOTTING

After delivery of tubes due in December, some tubes will be built without anode slots to determine whether they are necessary to prevent secondary emission from the anode.

3.9 SCREEN CURRENT

The high precision grid winding lathe is operating satisfactorily.. New mandrels have been made and are in use. The screen wire diameter is 0.0008 inches and hid behind every other 0.0012 grid wire. This is necessary to keep the screen dissipation low enough so as to prevent burn outs. Even though the grid lathe is of the high prevision type, it is necessary to respace some of the grid wires by hand after winding to insure good line up.

Some trouble was encountered during RF operation of tube number 1 which was attributable to primary screen emission. This appeared to load the output cavity and prevent sufficient swing of plate current to give good output power. Continued RF operation, even into the negative screen current region, appeared to minimize the screen emission effect. However, tube number 1 saturates on power output at about 20 watts. This may be due to its low resonant frequency and consequent mis-match to the cavity.

3.10 AMPLIFIER TEST SET

The 3000 megacycle driver-oscillator has been finalized and operates with a rectified RF feedback signal to hold constant power output. There is also a built in frequency cavity which gives a meter indication at 3000 megacycles $\pm$ about 15 megacycles.

The old amplifier from the previous contract consisted of a wave guide input cavity and a circular output cavity. Tuning of this circular cavity is restricted to about $\pm$ 15 megacycles. The difference between tubes is considerably greater than this frequency range. In addition, tuning of this circular cavity is very critical because of its small external dimensions compared to the tube itself. We are working on a double wave guide cavity to replace the old amplifier test cavity. It is intended that the new cavity shall tune at 3000 megacycles and have sufficient tuning range to cover all tubes. According to the final report of the previous contract, each tube was optimized for power output by tuning plate current and screen voltage. It was discovered that plate current and screen voltage have the same effect as tuning the cavity mechanically. It is felt that the tube can be operated under fixed plate voltage, plate current and screen voltage conditions with a fixed drive. Although the new cavity is improving gradually in power output, it has yet to achieve the performance of the old cavity.

3.11 RF STABILIZING AND LIFE TEST

To date we have done all RF stabilizing in the old amplifier test cavity. Effort has been spent on several modifications of an oscillator cavity at 2500 megacycles. This is also a double wave guide cavity design. Although the power output is increasing gradually it is still much below the proposed objective power output. Present efforts are being expended toward optimizing cavity impedance to more closely match the tube.

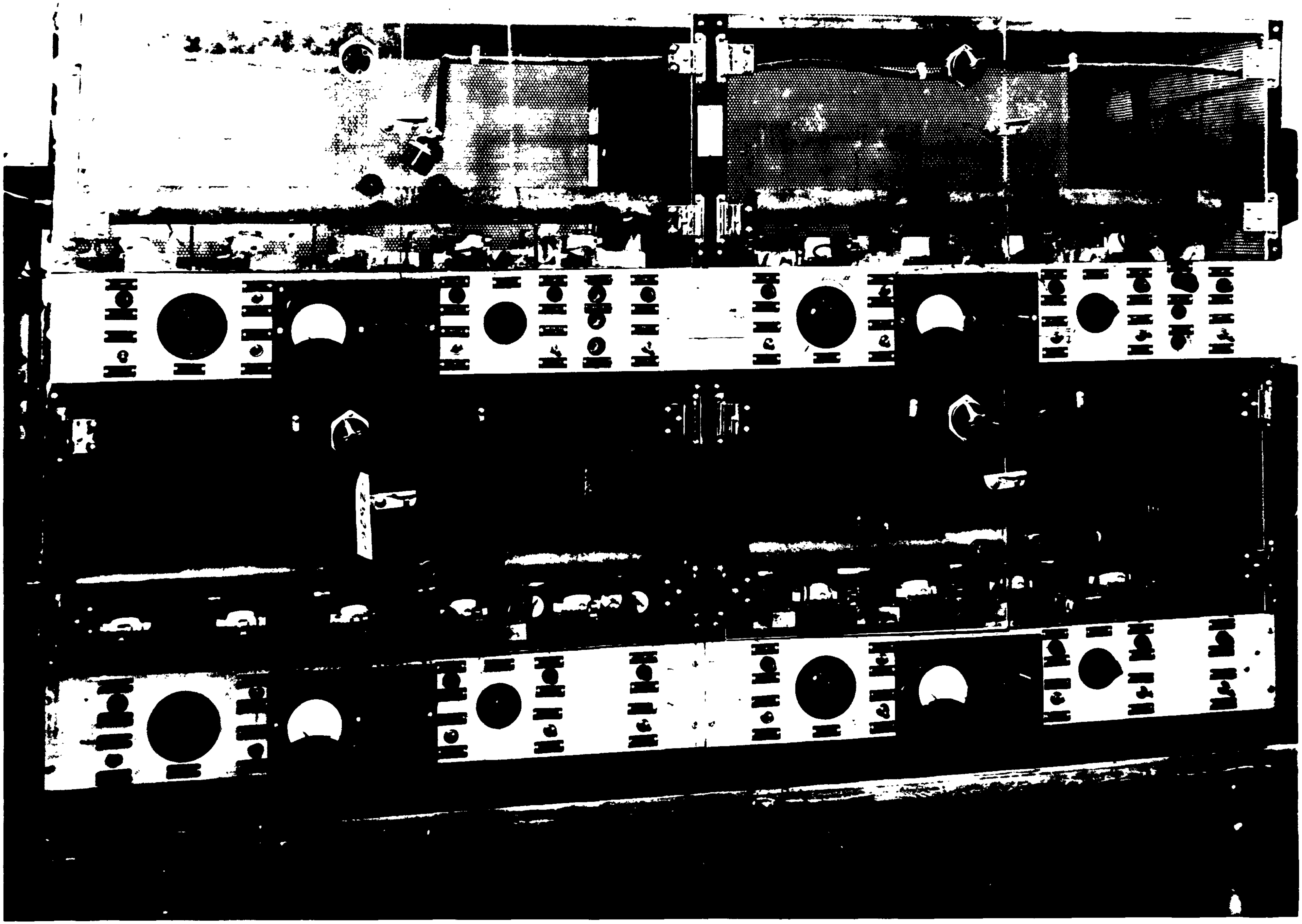
3.12 MISCELLANEOUS

Complete production drawings for the tube have been made. Engineering is reviewing these drawings and issuance awaits approval. The next three pages show photographs of equipment as follows:

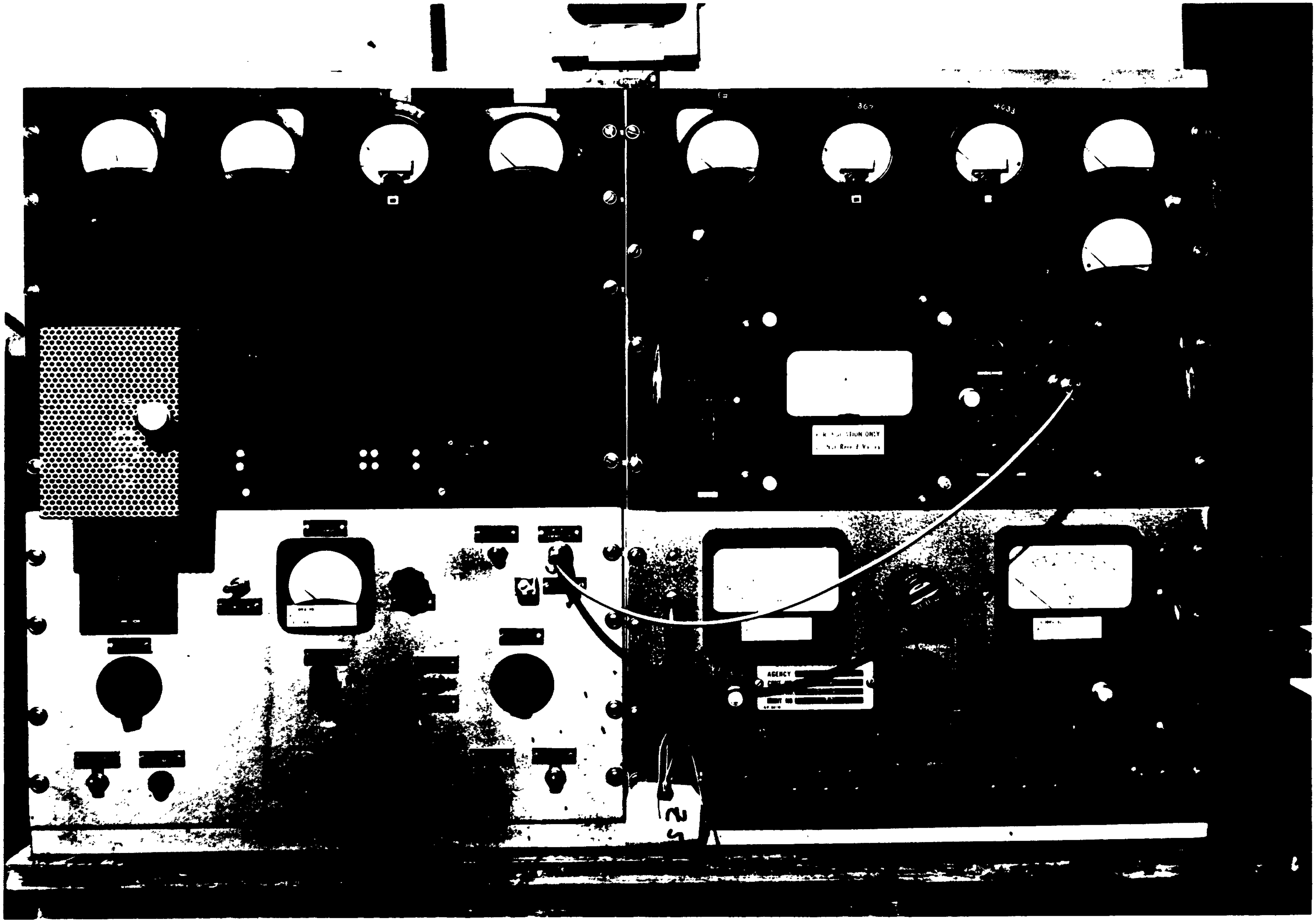
a. Low Voltage Aging Rack

b. Static Characteristic Test Set

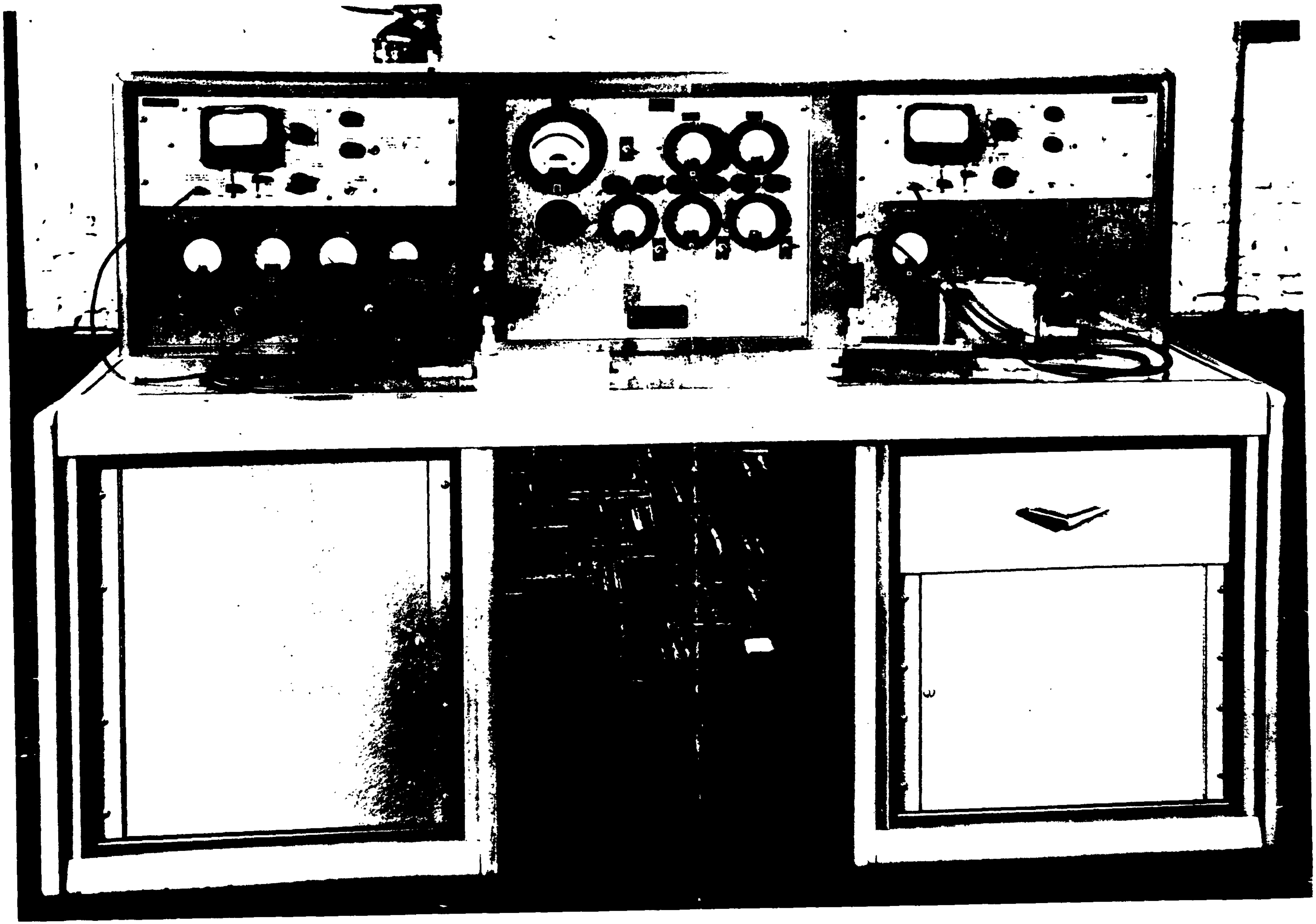
c. RF Amplifier Power Supply & Oscillator



Low Voltage Aging Rack



Static Characteristic Test Set



RF Amplifier Power Supply and Oscillator

4.0 CONCLUSIONS

Tube building has progressed on a somewhat slower schedule than had been originally anticipated. However, it is believed at this time that the scheduled ten tube delivery will be made on December 24. Aside from delays in tube building, the primary problem now appears to be in the RF cavity operation in both the amplifier test cavity and the stabilizing and life test oscillators. However, progress is being made in both of these areas.

5.0 PROGRAM FOR THE NEXT INTERVAL

The next quarter will be spent in building up the production rate of tubes, trying out the new exhaust sets, and completing all RF test equipment. Most of the tubes due on the next delivery date will be built during the next quarter, along with complete specification testing including some life test. The remaining unfinalized items of Section 3.0 will be tried and specified.

PROGRESS CHART - Z-5267 PEM
DA.36-039-SC-86735

	1962							1963												
	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J
I. BUILD 10 DESIGN TUBES																				
A. Purchase materials	(X)	(X)	(X)	X																
B. Check all parts & fits		(X)	(X)	X																
C. Purchase parts		(X)	(X)	(X)	X															
D. Check design of all fixturing			(X)	(X)	◯															
E. Purchase assembly fixtures				(X)	(X)	◯														
F. Purchase 4 brazing fixtures				(X)	(X)	( )														
G. Try fixtures					(X)	(X)														
H. Make sub-assemblies					(X)	(X)														
I. Build, exhaust & test tubes					(X)	(X)	X													
J. Life testing						X	X													
II. BUILD 30 DESIGN TUBES																				
A. Make sub-assemblies							X	X	X											
B. Build, exhaust & test tubes							X	X	X	X										
C. Life test tubes								X	X	X	X									
D. Propose final specification												X								
III. SUBMIT 10 PREPRODUCTION TUBES																				
A. Make sub-assemblies										X	X									
B. Build, exhaust & test tubes											X	X								
C. Life test tubes											X	X	X							
D. Perform pre-production in plant														X	X					
IV. BUILD TUBES AT 75 PER MONTH RATE																				
A. Build 6 more brazing fixtures									X	X	X									
B. Build up to final production rate												X	X	X						
C. Make sub-assemblies															X					
D. Build tubes																X				
E. Exhaust, age & test																X				
F. Life test																X	X			

X - Anticipated Progress
() - Actual Progress
◯ - Completed

PROGRESS CHART - Z-5267 PEM
DA.36-039-SC-86735

	1962							1963												
	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J
V. TUBE DESIGN IMPROVEMENTS																				
A. Tolerances & fixtures.																				
1. Review & revise		(X)	Ⓧ																	
2. Modify drawings		(X)	(X)	Ⓧ																
B. Anode ceramic																				
1. Design fixture			Ⓧ																	
2. Build fixture					Ⓧ															
3. Try fixture						Ⓧ														
C. Molybdenum contacts																				
1. Try slit contacts			Ⓧ																	
2. Make tools			(X)	Ⓧ																
3. Try parts					Ⓧ															
D. Super dry hydrogen																				
1. Order braze materials			Ⓧ																	
2. Try braze materials				(X)	Ⓧ															
3. Build tubes					(X)	(X)	X	X												
E. Cathode coating																				
1. Purchase special spray gun				Ⓧ																
2. Optimize coating procedure					(X)	(X)	X	X												
3. Build tubes						(X)	X	X	X	X	X									
4. Life test tubes							X	X	X	X	X									
F. Radiator																				
1. Design						X	X													
2. Purchase parts								X	X											
3. Build tubes										X	X									
G. Anode slotting																				
1. Purchase unslotted anodes							X													
2. Build tubes								X	X											
3. Test tubes										X										
H. Screen current																				
1. Wind trial grids					(X)	(X)	X	X												
2. Build tubes					(X)	(X)	X	X	X	X										
3. Evaluate results						(X)	X	X	X	X	X									

X - Anticipated Progress
() - Actual Progress
◯ - Completed

PROGRESS CHART - Z-5267 PEM
DA.36-039-SC-86735

	1962							1963												
	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J
VI. EXHAUST EQUIPMENT																				
A. Transfer equipment		X																		
B. Redesign equipment					X															
C. Rebuild sets						(X)	X													
D. Test for high vacuum								X	X	X	X									
VII. TEST EQUIPMENT																				
A. DC aging																				
1. Redesign			X																	
2. Rebuild				(X)	X															
B. AC aging																				
1. Design					X															
2. Build						X	X													
C. RF aging																				
1. Design					(X)	(X)														
2. Build						(X)	X													
D. RF amplifier test set																				
1. Design driver	(X)	(X)	X																	
2. Build driver			(X)	X																
3. Redesign amplifier				(X)	X															
4. Rebuild amplifier					(X)	(X)														
5. Redesign test set				○	X	X														
6. Rebuild test set					○	X	X													
E. RF life test set																				
1. Design oscillator cavity				(X)	(X)															
2. Build oscillator cavity					(X)	(X)														
3. Test oscillator cavity						(X)	X													
4. Design life test set						(X)	X													
5. Build life test set							X	X												
VIII. REPORTS																				
A. Quarterly				X			X			X			X			X				
B. Final																	X	X		
C. Inspection																				
1. Inspect parts			(X)	(X)	(X)	(X)	X	X	X	X	X	X								
2. Inspect sub-assemblies						(X)	X	X	X	X	X	X	X	X	X					
3. Process studies												X	X							
4. Write & submit report														X	X					
D. 200 per month production plan																	X	X	X	X

X - Anticipated Progress
( ) - Actual Progress
○ - Completed

6.0 PUBLICATIONS, REPORTS AND CONFERENCES

6.1 PUBLICATIONS - None

6.2 REPORTS -

Monthly Report No. 3
PEM for the Z-5267, 40 Watt, 3000 Mc Tetrode
by V. W. Amoth for the period from
1 August 1962 through 31 August 1962

Monthly Report No. 4
PEM for the Z-5267, 40 Watt, 3000 Mc Tetrode
by V. W. Amoth for the period from
1 September 1962 through 30 September 1962

Monthly Report No. 5
PEM for the Z-5267, 40 Watt, 3000 Mc Tetrode
by V. W. Amoth for the period from
1 October 1962 through 31 October 1962

Quarterly Report No. 1
PEM for the Z-5267, 40 Watt, 3000 Mc Tetrode
by V. W. Amoth for the period from
23 May 1962 through 31 August 1962

6.3 CONFERENCES - None

7.0 PERSONNEL

Engineering personnel qualifications not previously included in a previous report are described on the following page. Time spent on the program during this report period was as follows:

V. W. Amoth	228 hours
T. Bogucki	496 hours
W. H. Grant	63 hours
L. K. LaDue	448 hours
C. T. Jackson	145 hours
W. V. Shipley	360 hours
J. W. Stuart	34 hours
All other technical	12 hours
Total	1,786 hours

Submitted by:

V W Amoth

V. W. Amoth
Senior Design Engineer
Planar Tube Product Design
Receiving Tube Department

Approved by:

H. L. Thorson

H. L. Thorson
Manager Engineering
Planar Tube Product Design
Receiving Tube Department

MR. CHARLES T. JACKSON - EQUIPMENT ENGINEER - ENGINEERING TEST LABORATORY

Mr. Charles T. Jackson attended the University of Kentucky School of Engineering after serving thirteen months in the Navy as a radar technician.

Since coming to General Electric he has held a variety of positions and is currently an equipment engineer in the Engineering Test Laboratory with responsibility for practical designs for new equipment to meet improved testing requirements, and to improve designs on existing equipment.

GENERAL ELECTRIC COMPANY
ELECTRONICS COMPONENTS DIVISION
RECEIVING TUBE DEPARTMENT
OWENSBORO, KENTUCKY

SUBJECT: Second (2nd) Quarterly Report
Order No. 19057-PP-62-81-81
Contract No. DA-36-039SC-86735

	Number of Copies
Advisory Group on Electronic Devices 346 Broadway, 8th Floor New York 13, N.Y. ATTN: Chairman, Low Power Devices	2
Armed Services Technical Information Agency Document Service Center Arlington Hall Station Arlington 12, Virginia	10
Commanding Officer U. S. Army Electronics Research & Development Agency Attn: SELRA/SL-PRM Mr. Sheppard Fort Monmouth, N. J.	1
Commanding General U.S. Army Electronics Command ATTN: AMSEL-PP (PD-5b) Fort Monmouth, N. J.	1
Commanding Officer U.S. Army Electronics Materiel Support Agency ATTN: SELMS-PFE, Mr E. Anderson Fort Monmouth, N.J.	1
Canadian Liaison Officer Office of the Chief Signal Officer Department of the Army The Pentagon Washington 25, D.C.	1
U.S. Army Electronics Materiel Agency ATTN: Chief, Quality Assurance Operations Div. 225 South 18th Street Philadelphia 3, Pa.	1
Bell Telephone Laboratories Murray Hill, New Jersey ATTN: Librarian	1
Sylvania Electric Company Emporium, Pa ATTN: Mr C. Douglas	1
Radio Corporation of America Harrison, N. J. ATTN: Mr Clarence West	1

GENERAL ELECTRIC COMPANY
ELECTRONICS COMPONENTS DIVISION
RECEIVING TUBE DEPARTMENT
OWENSBORO, KENTUCKY

SUBJECT: Second (2nd) Quarterly Report
Order No. 19057-PP-62-81-81
Contract No. DA-36-039SC-86735

	Number of Copies
Raytheon Company Waltham 54, Massachusetts ATTN: Manager, Government Relations	1
Tung-Sol Electric, Inc Bloomfield, N. J. ATTN: Manager, Government Relations	1
U.S. Army Electronics Materiel Agency ATTN: SELMA-R2b 225 South 18th Street Philadelphia 3, Pa.	Balances of Copies